DOCUMENT RESUME

ED 196 717 SE 033 767

AUTHOR	Cobern, Morris; Conlon, Nancy
TITLE	Occupational Mobility of Scientists and Engineers. Special Report.
INSTITUTION	National Science Foundation, Washington, D.C. Div. of Science Resources Studies.
REPORT NO	NSF-80-317
PUB DATE	80
NOTE	25p.; Contains shaded charts and graphs which may not reproduce well.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (no price quoted).
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Career Change; *Employment Patterns; *Engineers; Job Satisfaction; Labor Force; *Occupational Mobility; Science Education; *Scientists

ABSTRACT

This report describes the occupational mobility of science and engineering (S/E) personnel. This analysis is part of the National Science Foundation's Division of Science Resources Studies program designed to enhance the understanding of the operations of the S/E labor market. Charts represent information discussed in the text regarding such topics as: (1) change in economic indicators affecting S/E employment; (2) 1978 occupational distribution of 1972 occupational cohorts of experienced scientists and engineers; (3) distribution of 1972 experienced S/E work force employed in non-S/E jobs in 1978 by reason for movement; and (4) occupational mobility of experienced S/E by selected characteristics, 1972-78. Appendices include technical notes, a bibliography, and statistical tables. (CS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED196717

occupational mobility of scientists and engineers

national science foundation

special report
NSF 80-317

SE 033 767

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

related publications

Science Resources Studies Highlights

	NSF Number	Price
"National Sample of Scientists and Engineers: Changes in Employment, 1972-74 and 1974-76"	77-322	-----
"National Sample of Scientists and Engineers: Median Annual Salaries, 1974"	75-332	-----
"Selected Employment and Labor Force Characteristics of the Redefined Science and Engineering Population"	75-326	-----
"National Sample of Scientists and Engineers: Participation in National Programs and Changes in Educational Attainment, 1972-74"	75-317	-----
"National Sample of Scientists and Engineers: Changes in Employment, 1970-72 and 1972-74"	75-309	-----
"The 1972 Scientist and Engineer Population Redefined"	75-305	-----

Detailed Statistical Tables

Characteristics of Experienced Scientists and Engineers		
1978	79-322	-----
1976	78-305	-----
The 1972 Scientist and Engineer Population Redefined		
Volume 2. Labor Force and Employment Characteristics. Engineers, by Field	76-306	-----

Reports

Characteristics of the National Sample of Scientists and Engineers, 1974		
Part 1. Demographic and Educational	75-333	$1.90
Part 2. Employment	76-323	$2.80
Part 3. Geographic	76-330	$2.00
The 1972 Scientist and Engineer Population Redefined		
Volume 1. Demographic, Educational and Professional Characteristics	75-313	$3.70
Volume 2. Labor Force and Employment Characteristics	75-327	$2.65

Availability of Publications

Those publications marked with a price should be obtained directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Where no price is listed, single copies may be obtained gratis from the National Science Foundation, Washington, D.C. 20550.

(See inside back cover for Other Science Resources Publications.)

foreword

Significant changes have occurred in the employment patterns of various scientific and technical occupations over the past two decades. Rates of change differed among fields as well as between employing sectors of the economy in which scientists and engineers play significant roles. Such events have frequently produced dramatic changes in labor market conditions for scientists and engineers. This publication examines one important mechanism of labor market adjustment—occupational mobility. Although industrial, geographic, and job mobility are important aspects of this phenomenon, this report focuses on movement into, out of, and between science and engineering (S/E) occupations. This analysis is part of the National Science Foundation's Division of Science Resources Studies program designed to enhance the understanding of the operations of the S/E labor market.

Charles E. Falk
Director, Division of Science
Resources Studies
Directorate for Scientific, Technological,
and International Affairs

June 1980

acknowledgments

This report was prepared in the Division of Science Resources Studies by Morris Cobern and Nancy Conlon, under the direction of Joel Barries, Study Director, Utilization Studies Group and Alan Fechter, Head, Scientific and Technical Personnel Studies Section. Wilma Molitor, Steven W. C. Lowe, and Melissa Lane provided statistical assistance.

The data which provided the basis for this study were collected and tabulated for the National Science Foundation by the Population Division of the Bureau of the Census, primarily by Murray Weitzman, Paula J. Schneider, Thomas Palumbo, Mary K. Friday, and Anita Chiera.

contents

Page

Highlights 1

Part 1. Introduction 2

Part 2. Background 3

Part 3. Occupational Mobility 5
- Occupation 5
  - Age 7
  - Education 7
  - Race 8
  - Sex 8
  - Changing Labor Market Conditions 8

Appendixes:
- A. Technical Notes 12
- B. Bibliography 13
- C. Statistical Tables 15

highlights

- About one out of four persons employed in science and engineering (S/E) occupations in 1972 changed to different occupations by 1978. The bulk of this movement—approximately four-fifths—was to non-S/E occupations, primarily in management and administration.
- A very small proportion, 6 percent, of those moving to non-S/E occupations did so because of the absence of job opportunities in S/E labor markets.
- The largest occupational movement among S/E occupations was out of mathematical sciences, where demand was weak, into computer specialities and engineering, where demand was strong. By 1978 about 8 percent of those employed as mathematicians in 1972 were employed as engineers. Another 7 percent had become computer specialists.
- Occupational mobility appeared inversely related to age. The youngest age group, those "under 35," reported the highest mobility rate, 5.7 percent per year, for the 1972-78 period. The oldest group, "45 and over," reported the lowest rate, 3.7 percent per year.
- Occupational mobility showed a relation to the level of educational attainment. Doctorate-holders, in general, were less apt to change occupations than others in the same occupation with less education.
- Women scientists and engineers changed occupations more than men over the 1972-78 period (35 percent versus 26 percent). The observed sex differential was entirely attributable to the tendency of women scientists and engineers to be concentrated in occupations with relatively high rates of out mobility. No systematic sex differences remain after differences in occupational distributions have been accounted for.
- In general, blacks exhibited slightly more occupational mobility between 1972 and 1978 than whites (32 percent versus 26 percent), and Asians were considerably less mobile than either group (16 percent).
- In spite of major differences in the performance of the economy between the periods 1968-72 and 1972-78, occupational mobility patterns remained generally stable.
- Occupational mobility between S/E and non-S/E jobs has implications for both the market adjustment process and the potential for efficient utilization of those with S/E skills. The magnitude of the outflows suggests that this has been a very common adjustment to excess supply conditions in the S/E labor market. Involuntary employment in non-S/E jobs caused by an absence of job opportunities represents underemployment of S/E skills. However, the relatively low proportion of the respondents who reported they moved to non-S/E occupations because of the absence of job opportunities suggests that very little underemployment existed.

part 1.

introduction

An important dimension of short-run labor market adjustment to shifts in demand is the movement of workers between jobs, employers, occupations, and geographic locations. The major source of new scientists and engineers, new graduates from institutions of higher education, historically has lagged in response to labor market changes, in part because of the long lead time required to move through the education pipeline. Thus, occupational change is the major form of short-run accommodation to changes in market conditions.

The study of this particular type of response is important for three reasons. First, it provides the basis for identifying closely related occupations which are part of the reservoir of skills available to meet shifting economic priorities. Second, it measures differences in the labor market behavior of segments of the work force. Finally, an understanding of these flows and their determinants for individual occupations can facilitate evaluation of the consequences of alternative demand scenarios.

This report addresses the movements and relationships between occupations during the decade 1968-78. It examines the propensity to stay in or leave a job by characteristics such as occupation, age, sex, race, and degree level. While discussions of these movements are primarily descriptive, possible causal relationships are discussed.

Two data bases are used in this report. The 1968-72 data emanate from about 70,000 respondents to a 1972 NSF survey. The sample for this survey consisted of individuals who, in response to the 1970 Census of Population, indicated that they were a scientist or engineer, or in a related job. The 1972-78 data are based on about 50,000 respondents to the 1972 survey, who were then resurveyed in 1974, 1976, and 1978. (See technical notes.)

The populations used in this study were working as scientists and engineers in both 1970 and 1972. The samples exclude new entrants to the labor force after 1970. Therefore, the average age of the sample is higher and the mobility rates lower than would be the case had new entrants been included. Because of the exclusion of new entrants, the individuals referred to in the tables and charts are designated as "experienced" scientists and engineers. The "experienced" populations comprised about three-fifths of the S/E labor force in 1978.

part 2.

background

Occupational mobility patterns are affected by the state of the economy. The balance between the supply and demand for workers and jobs is one of the determinants of job and occupational mobility. Mobility patterns differ in periods of rising demand compared to periods of decline or stability in the labor market for scientists and engineers. Chart 1 depicts the rate of change of S/E employment in relation to several economic indicators for the period 1960-78.

The sixties were characterized by rapid growth of demand for scientists and engineers in all sectors, spurred by increased space-related research and development, for which real spending increased from $600 million in 1960 to $5.9 billion by 1965.[1] Defense-related

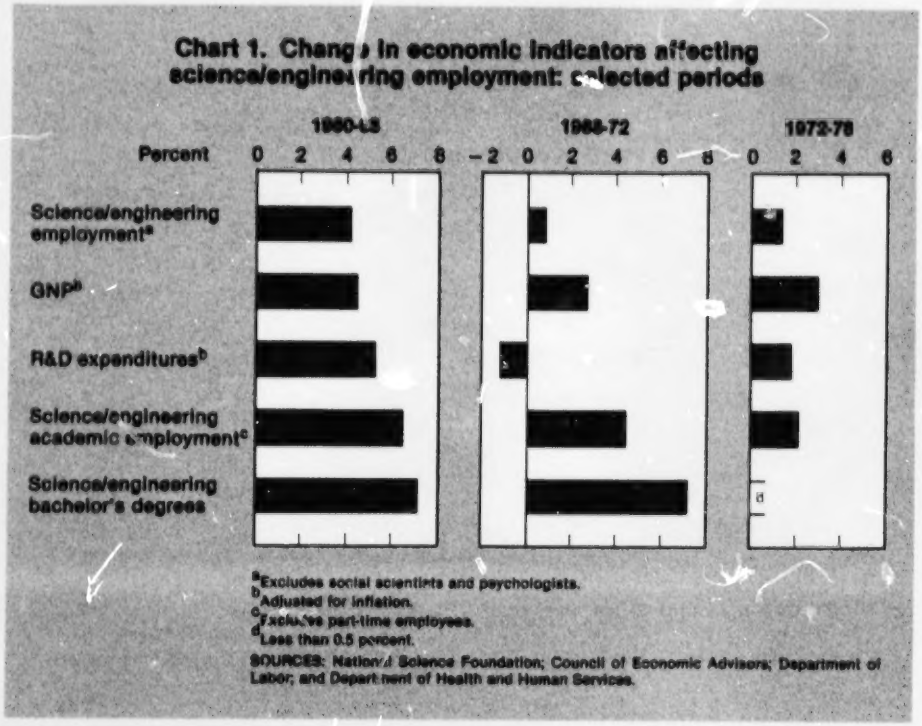


Chart 1. Change in economic indicators affecting science/engineering employment: selected periods

[a] Excludes social scientists and psychologists.
[b] Adjusted for inflation.
[c] Excludes part-time employees.
[d] Less than 0.5 percent.

SOURCES: National Science Foundation; Council of Economic Advisors; Department of Labor; and Department of Health and Human Services.

[1] National Science Foundation, *National Patterns of R&D Resources: Funds & Personnel in the United States, 1953—1978-79* (NSF 78-313) (Washington, D.C.: U.S. Government Printing Office, 1978), Tables B-5 and B-9.

activities also increased, as well as new initiatives on domestic programs. Total corporate profits increased steadily between 1960 and 1968 and the gross national product (GNP) increased between 1960 and 1969, marking the longest sustained period of economic growth since 1929.[2] College enrollment grew dramatically in the sixties, more than doubling from 1960 to 1969, accompanied by a doubling of total faculty positions.[3] In this environment of strong demand in all sectors of the economy the number of employed natural scientists and engineers grew by 42 percent, almost twice as fast as the total number of civilian, nonagricultural workers.[4]

The late sixties and the early seventies posed a totally changed environment for S/E labor markets. Spending for research and development, corporate profits, and GNP growth began to fall. Unemployment of engineers—especially those previously working in defense/space work—increased from 0.7 percent in 1968 to 2.9 percent in 1971. Degrees in S/E programs leveled off and began to decline, and scientists and engineers hired by academic institutions were increasingly employed in temporary, nontenure track and part-time positions.

In the midseventies employment demand for scientists and engineers grew once again, primarily in response to greater industrial production and increased R&D expenditure.[5]

[2]Council of Economic Advisors, *Economic Report of the President* (Washington, D.C.: U.S. Government Printing Office, January 1980), tables B-2 and B-80.

[3]Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1976* (Washington, D.C.: U.S. Government Printing Office, 1976), table 233.

[4]Department of Labor, Bureau of Labor Statistics, *Employment of Scientists and Engineers, 1950-1970*, Bulletin 1781 (Washington, D.C.: U.S. Government Printing Office, 1973.)

[5]For an analysis of the sectoral trends in employment of scientists and engineers in this period, see National Science Foundation, "Employment of Scientists and Engineers Increased Between 1976 and 1978 But Declined in Some Science Fields," *Science Resources Studies Highlights* (NSF 80-305) (Washington, D.C., March 19, 1980.)

part 3.

occupational mobility

This section describes patterns of occupational mobility for the 1972-78 period and their differences from the 1968-72 period. The earlier period underwent a relatively declining demand for scientists and engineers, while the latter period showed growth; therefore, the data were examined for changes in occupational mobility patterns between the periods.

Occupational mobility is defined as a worker's change from a major occupational S/E group to either another major S/E group, a managerial and administrative position, or another non-S/E occupation. Four-fifths of all the occupational mobility of scientists and engineers was to non-S/E occupations. The major S/E groups are engineers, computer specialists, mathematicians and statisticians, physical scientists, biological scientists, social scientists, psychologists, and "other" scientists.

occupation

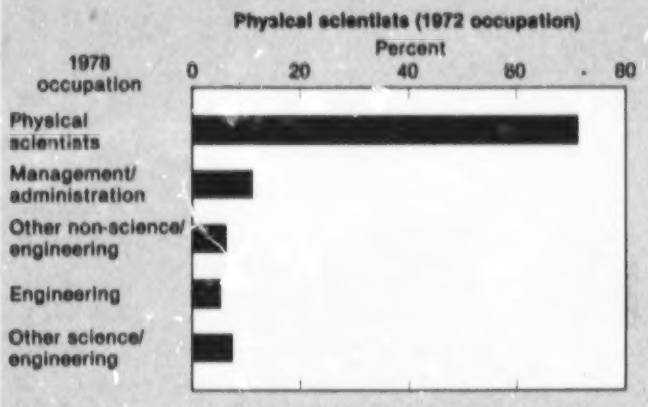
Over 25 percent of all scientists and engineers changed their major occupational group of employment between the base year of 1972 and 1978. The most occupationally mobile S/E group was mathematicians—over two-fifths moved to another occupational group over the period. (See chart 2 and appendix table C-1.) Psychologists and engineers were the least occupationally mobile—20 percent and 23 percent, respectively.

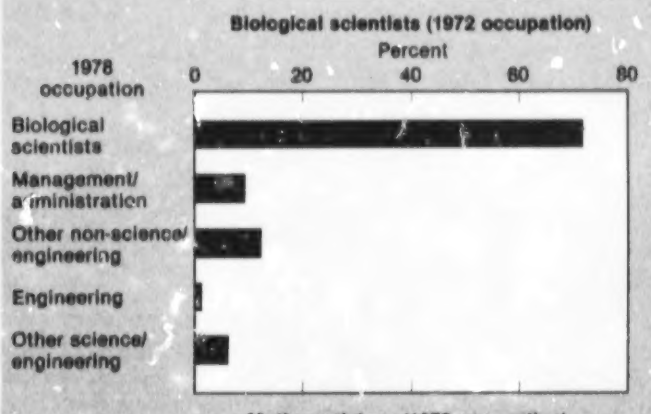
The occupations with the greatest relative mobility to non-S/E jobs were social scientists (32 percent), computer specialists (26 percent), and mathematicians (23 percent). The high rate of mobility to non-S/E jobs of social scientists and mathematicians reflects relatively weak demand conditions in these fields. The high rate of mobility to non-S/E fields of computer specialists reflects upward career movements to managerial and administrative positions rather than weak demand conditions. Physical scientists were the least mobile to non-S/E jobs (chart 2).

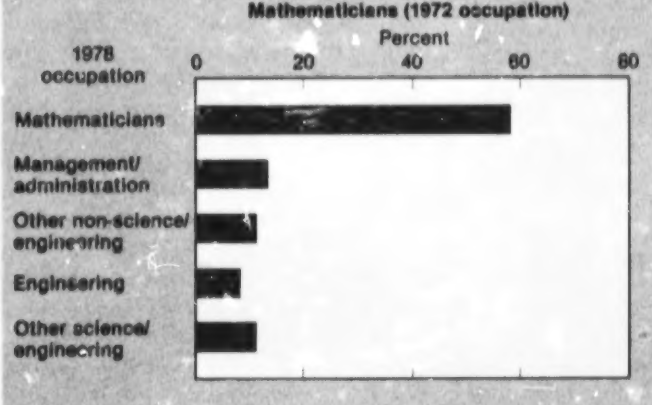
Of those changing to non-S/E occupations between 1972 and 1978, two-thirds made the move to manager and administrator occupations and only one-third to other non-S/E fields. Of those who moved to non-S/E jobs, computer specialists had the greatest relative movement to managerial and administrative positions (3.5:1), followed by engineers (2.7:1). The smallest relative movement to managerial and administrative positions was among psychologists (0.7:1) and biological scientists (0.8:1).

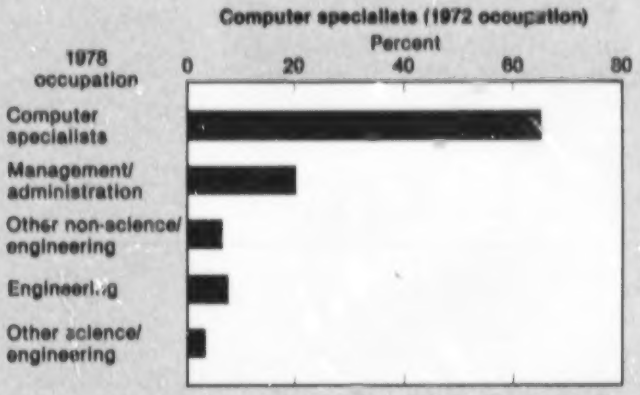
While the magnitude of outmobility from S/E jobs was large, it was not

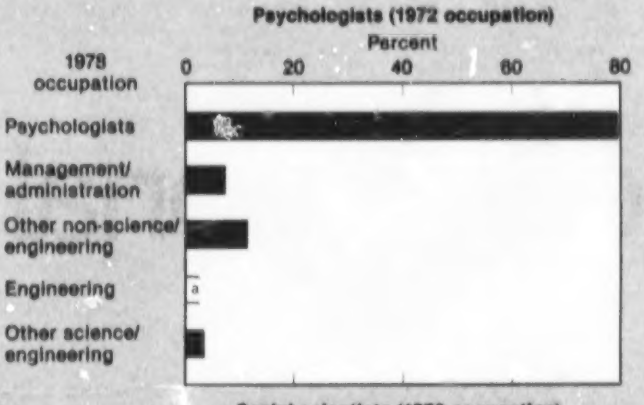
Chart 2. 1978 occupational distribution of 1972 occupational cohorts of experienced scientists and engineers

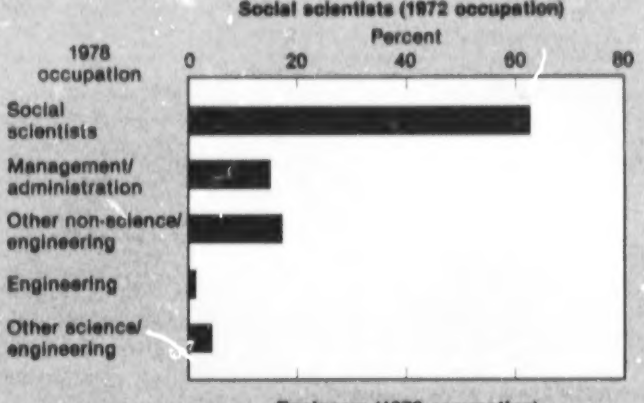


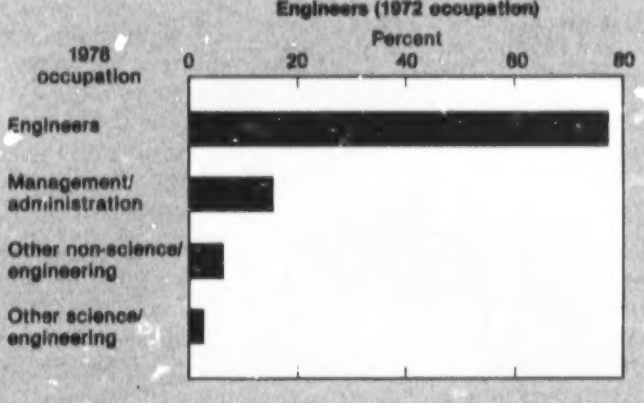












[a] Less than 0.05 percent.

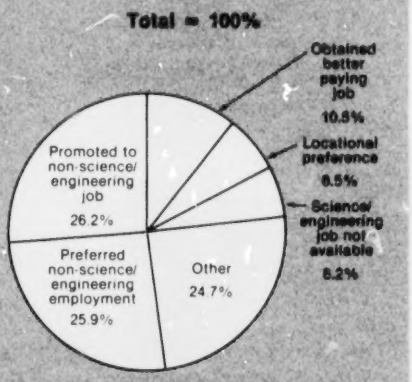
SOURCE: National Science Foundation

caused by a lack of S/E jobs. Of the 1972 scientists and engineers that had changed to non-S/E jobs by 1978, only 6 percent reported that it was because no S/E job was available. The largest proportion of the non-S/E employed (over one-half) reported that they had either been "promoted out" of their S/E position or that they "preferred" non-S/E employment (chart 3).

The second category of mobility, to a different S/E occupational group, accounted for 5 percent of all scientists and engineers (or one-fifth of the occupationally mobile scientists and engineers) over the 1972-78 period. Mobility among S/E jobs was generally limited to a few fields. Of the 56 possible occupational transfers considered (7 alternatives for 8 original S/E occupations) in the 1972-78 period, only 4 displayed movement of 5 percent or more.[6] The most dramatic movement was out of mathematical sciences (where demand was weak) into computer specialties and engineering (where demand was strong). About 8 percent of those employed as mathematicians in 1972 were engineers in 1978; about 7 percent were computer specialists.

The low rate of outflow for engineers may reflect the strong demand for engineers in the late seventies, a period in which shortages for some engineering specialties were being reported. While computer specialists had moderately high outmobility—about one-third—most of this flow was to management and administrative jobs, reflecting the rapid growth of the computer field. Another indicator of the field's growth was the attraction of mathematicians to computer specialties.[7] Almost 7 percent of the mathematicians became computer specialists between 1972 and 1978. The low rate of occupational change of psychologists indicates a lack of commonality with other S/E occupations (only 3 percent moved to these occupations) and the small population flowing to managerial occupations may reflect the "private practice" nature of jobs in psychology. Social scientist also had little in common with other S/E occupations; however, 15 percent moved to managerial or administrative jobs.

Chart 3. Distribution of 1972 experienced science/engineering work force employed in non-science/engineering jobs in 1978 by reason for movement



SOURCE: National Science Foundation

age

Occupational mobility of scientists and engineers was inversely related to age (chart 4). While further research is needed to explain the reasons for this relationship among scientists and engineers, it has been shown that in the overall labor force the amount of on-the-job training acquired in an occupation through labor market experience increases as workers age. Almost one-third of all scientists and engineers under 35 changed jobs in the 6-year period, compared with one-fourth of those between the ages of 35 and 44 and one-fifth of those 45 and older. This relationshp may also reflect other factors associated with a change of employer or location which may accompany a change in occupation. Workers may be more reluctant to undergo an occupation change as they age because of vested interest in pension plans and community attachments. Also, younger workers, who have accumulated less on-the-job training, are more vulnerable to layoffs than older workers. This may produce greater cyclical sensitivity in the rate of occupational mobility of younger workers compared to older workers.[8] While age has an inverse relationship with mobility to management and administration, outmobility to other non-S/E jobs is less influenced by age (appendix table C-2).

education

S/E doctorate-holders were less likely to change occupations than their colleagues with less education, reflecting the highly specialized nature of and large investment in their formal training (chart 4 and appendix table C-3). Also, doctorate-holders may accumulate more "specific" on-the-job training than nondoctorates, which may deter firms from laying them off.[9] Interestingly, while the group with the most training, the Ph.D.'s, had the lowest rate of occupational mobility (22 percent), the group with the least training, the bachelor's degree-holders, did not have the highest rate (25 percent). The absence of a systematic relationship between mobility and level of highest degree could be explained by the relative levels of coincidence of the degree field with the occupation. During the 1972-78 period the master's degree-holders had the lowest coincidence (78 percent had the master's in a field of study coincident with their 1972 occupation) followed by bachelor's degree-holders (83 percent), while the Ph.D.'s had the greatest coincidence (86 percent). The relatively low coincidence rate for those workers whose highest degree was the master's suggests that

[6] These data, examined by broad occupational group, mask movements which undoubtedly occur between specialized fields within the groups, e.g., physicist to chemist within the physical scientists group and mechanical engineer to aerospace engineer within the engineer group.

[7] Unpublished data of the Bureau of Labor Statistics reveal that between 1970 and 1976, the number employed in computer specialties grew by 114,784, that for engineering by 108,727—the two fastest growing S/E fields. The third ranking field was social sciences which showed an increase of only 51,164 employed. Computer specialties and engineering are also fields with high proportions of baccalaureates, making entry into these fields easier than other fields which more often require graduate degrees for entry.

[8] Lowell E. Gallaway, "Age and Labor Mobility Patterns," *The Southern Economic Journal*, October 1969, p. 171.

[9] Jacob Mincer, *Schooling, Experience and Earnings* (New York: National Bureau of Economic Research, 1974), pp. 30-31.

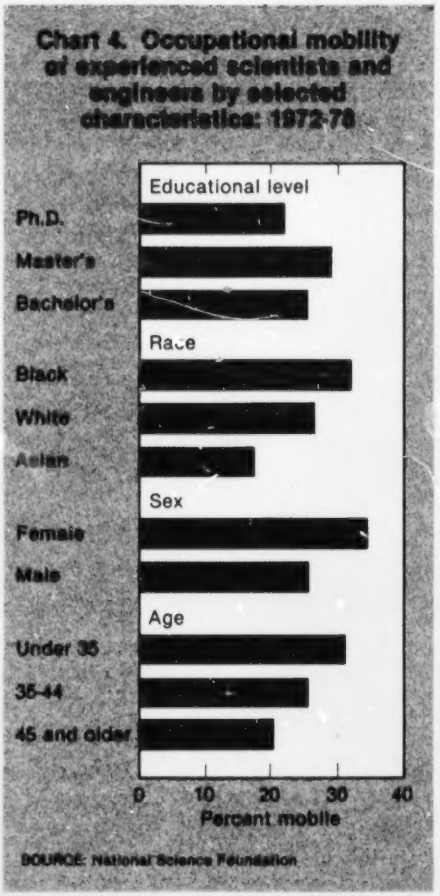
training outside the field of an individual's occupation facilitates movement to another occupation. The case of an engineer who earns a master's degree in business administration comes readily to mind. Most likely, an individual wishing to remain in his or her occupation would not earn a master's in a different field.

In addition, master's degree-holders tend to be, on the average, somewhat younger than bachelor's degree-holders and, as discussed previously, younger workers tend to be more mobile than their older colleagues. In 1978, 16 percent of the master's degree-holders were under 35 years old, compared to 11 percent of those with only baccalaureates. At the older end, 61 percent of the baccalaureates were 45 years and over, compared to 47 percent of the master's degree-holders. Thus, two factors likely account for a greater degree of mobility of those scientists and engineers with master's than bachelor's degrees. First, the use of master's degrees to prepare for new occupations; and, second, the master's degree-holders were, on the average, younger than those with only a bachelor's degree.

race

Black scientists and engineers had a higher occupational mobility rate over the 1972-78 period than whites (32 percent versus 26 percent). Asians had the lowest rate (chart 4 and appendix table C-4). The low mobility of Asians was consistent with their higher level of education—30 percent held the doctorate compared to 11 percent each of the black and white S/E groups. There was no significant difference in age distribution between blacks and the other groups to account for their high mobility, but blacks were not as concentrated in engineering (45 percent versus 70 percent of whites), a less mobile occupation. Given the same occupational distribution as whites, the black mobility rates would be reduced slightly to about 30 percent, indicating that field distribution was not the sole determinant of racial differences in occupational mobility.

For all S/E occupations combined, black scientists and engineers moved into management and administrative positions at the same rate as did whites—15 percent over the 1972-78 period. Thus, the overall difference in black S/E occupational mobility was entirely attributable to movement to other non-S/E occupations—12 percent of the black versus 6.9 percent of the white. (Appendix table C-4 shows the average annual mobility by race and occupation.)



sex

Women were more mobile than men between 1972 and 1978 (35 percent versus 26 percent) (chart 4). However, the difference was entirely attributable to women's concentration in more mobile scientific occupations in 1972 rather than in engineering (94 percent of women and 34 percent of men were scientists). If male scientists and engineers had had the same occupational distribution as females in 1972, male mobility would have been identical to that of women.

S/E women moved into management and administrative positions at a lower average rate than males (10 percent versus 15 percent); however, there was parity among biological scientists, psychologists, and social scientists. Women also had a higher average mobility to other non-S/E occupations (18 percent versus 6 percent). These higher rates were found in all occupational groups except psychology where mobility was equal between the sexes (appendix table C-5).

changing labor market conditions

Although labor market conditions for scientists and engineers in the late sixties and early seventies differed markedly from those of the mid- and late seventies, general patterns of occupational mobility were similar. The earlier years showed large decreases in defense, space-related, and commercially sponsored research, development, and production (chart 1). Unemployment of scientists and engineers peaked as the academic institutions continued to graduate record numbers of S/E-degree recipients. Nevertheless, for all scientists and engineers, the estimated outmobility was similar in the 1968-72 and 1972-78 periods, about 4.4 percent per year, although there were differences between the periods for some occupational and demographic groups.

In both periods mathematicians were the most occupationally mobile while psychologists were the least mobile (appendix table C-6). In both periods all the occupations, except computer specialists, maintained the same relative ranking of their propensity to change occupations. Computer specialists were among the least mobile in the 1968-72 period and the second most mobile during 1972-78. The increased mobility of computer specialists probably resulted from the rapid growth in the field of computer technology, and the movement of experienced computer specialists to management positions. In the 1972-78 period computer specialists had the highest propensity to move to management positions of any of the S/E occupations (chart 2).

Between the two time periods, some

differences appeared in occupational mobility patterns by age and education levels. In the 1972-78 period scientists and engineers less than 35 years old were more mobile than their older colleagues. While the 1972-78 mobility of the younger group increased substantially compared to 1968-72, mobility of the over 35-year-olds declined (appendix table C-6).[10] However, little systematic relationship existed between age and mobility in the 1968-72 period. This suggests that, while older workers are generally less mobile (i.e., in periods of both weak and strong demand), the relatively poorer job opportunities during the earlier period inhibited mobility of the younger population.

With respect to educational attainment, the most distinct patterns of change between the two periods was for doctorate-level scientists, who were generally more occupationally mobile in the 1968-72 period (appendix table C-6). This phenomenon may reflect a pushing-out effect resulting from poor employment opportunities caused by the substantial drop in R&D funding during the 1968-72 period, an activity in which doctorate scientists and engineers were highly concentrated. The recovery of R&D activities over the 1972-78 period could have contributed to the observed reduction in occupational mobility for the S/E doctorates. (Total S/E employment in research and development grew at a 2.3-percent annual rate during the later period, compared to a decrease of about 1 percent per year over the 1968-72 period.)

No significant change occurred in the pattern of movement between occupations over the two periods for S/E women who generally followed the overall occupational patterns (appendix table C-6). Comparable data for minorities were not available.

[10] The age designation of the sample for 1968-72 and 1972-78 was as of the last year of each period.

appendixes

A. Technical Notes
B. Bibliography
C. Statistical Tables

appendix a

technical notes

Data for mobility patterns of the 1972-78 period are from a sample survey of persons who reported their occupation as scientist or engineer in the 1970 Census of Population and who were surveyed in 1972 and resurveyed in 1974, 1976, and 1978. A sample of 50,093 representing a population of 1,400,000 scientists and engineers (the "Experienced Sample") were identified from the 1970 Census. The sample for the 1972-78 analysis included approximately 30,000 persons who responded in both years. The occupational mobility data for the period 1968-72 is based on responses to a retrospective question about employment asked in 1972 of 75,000 persons representing 1,037,000 persons who were in scientific or engineering or closely related occupations in 1970.

For further detail and explanations about the questionnaires, definitions, weighting and estimating procedures, sources of data, criteria for fields of science and engineering, sample selection, and analysis of responses see:

Characteristics of Experienced Scientists and Engineers (Detailed Statistical Tables)

1978 (NSF 79-322)
1976 (NSF 78-305)

The above publications are available gratis from the Division of Science Resources Studies, National Science Foundation, Washington, D.C. 20550.

Characteristics of the National Sample of Scientists and Engineers, 1974 (Detailed Statistical Tables)

Part 1. Demographic and Educational (NSF 75-333) (PB 253444/AS, $5.00)
Part 2. Employment (NSF 76-323) (PB264671/AS, $1.75)
Part 3. Geographic (NSF 76-330) (PB265681/AS, $5.00)

For the 1968-72 data see:

The 1972 Scientist and Engineer Population Redefined

Volume 1. Demographic, Educational, and Professional Characteristics (NSF 75-313) (PB 253184/AS, $7.75)
Volume 2. Labor Force and Employment Characteristics (NSF 75-327) (PB253604/AS, $6.00)

The above publications are available from the National Technical Information Service, Department of Commerce, Springfield, Virginia 22151. PB number and price are in parentheses.

appendix b

bibliography

Apgar, W. C., Jr. *Migration as Investment: Some Further Considerations*, Discussion Paper No. 64, Cambridge, Mass.: Harvard University, Program on Regional and Urban Economics, May 1970.

Becker, G. S. *Human Capital*, 2nd edition. New York: National Bureau of Economic Research, 1972.

Bowles, S. "Migration as Investment: Empirical Tests of the Human Investment Approach to Geographical Mobility," *Review of Economics and Statistics*, Vol. LII, No. 4, Nov. 1970, pp. 356-62.

Bowman, M. J. and R. G. Myers. "Schooling, Experience, and Gains and Losses in Human Capital through Migration," *Journal of the American Statistical Association*, Sept. 1967, pp. 875-98.

Brown, D. *The Mobile Professors*. Washington, D.C.: American Council on Education, 1967.

Commerce, Department of, Bureau of the Census, "Mobility of the Population of the United States, March 1970 to March 1975," *Current Population Reports*, Series P. 20, No. 285. Washington, D.C.: U.S. Government Printing Office, 1975.

Fein, R. "Educational Patterns in Southern Migration," *Southern Economic Journal*, Vol. 32, July 1965, pp. 106-124.

Fields, G. "Place-to-Place Migration: Some New Evidence," *Review of Economics and Statistics*, Vol. LXI, February 1979, pp. 21-32.

Folger, J. K. "Models in Migration," *Selected Studies of Migration Since World War II*. New York: Milbank Memorial Fund, 1958, pp. 155-65.

Folger, J., H. Astin, and P. Bayer. *Human Resources and Higher Education*. New York: Russell Sage Foundation, 1970.

Gallaway, L. E. "Age and Labor Mobility Patterns," *Southern Economic Journal*, Vol. 26, October 1969, pp. 171-1801.

Gallaway, L. E., R. F. Gilbert, and P. E. Smith. "The Economics of Labor Mobility: An Empirical Analysis," *Western Economic Journal*, June 1967, pp. 211-23.

Greenwood, M. J. "Research on Internal Migration in the United States: A Survey," *Journal of Economic Literature*, Vol XIII, No. 2, June 1975, pp. 397-433.

_____. "The Geographic Mobility of College Graduates," *The Journal of Human Resources*, Vol. VIII, No. 4, Fall 1973, pp. 506-15.

_____. "An Analysis of the Determinants of Geographic Labor Mobility in the United States," *Review of Economics and Statistics*, Vol. LI, No. 2, May 1969, pp. 189-94.

Kleiner, M. *An Analysis of Interregional Migration for Manpower Planning*, Document 133. Urbana, Ill.: Center for Advanced Computation, 1974.

Kottis, A. "Mobility and Human Capital Theory: The Education, Age, Race, and Income Characteristics of Migrants," *Annals of Regional Science*, Vol. 6, No. 1, June 1972, pp. 41-60.

Labor, Department of. *Why Families Move, A Model of the Geographic Mobility of Married Couples*, R&D Monograph 48 by J. DeVanzo. Washington, D.C.: U.S. Government Printing Office, 1967.

Ladinsky, J. "Sources of Geographic Mobility Among Professional Workers: A Multivariate Analysis," *Demography*, Vol. IV, No. 1, 1967, pp. 293-309.

_____. "The Geographic Mobility of Professional and Technical Manpower," *Journal of Human Resources*, Vol. V, No. 4, Fall 1967, pp. 475-94.

Langley, P. C. "The Private Gains to Long-Distance Migration in the United States," *The Economic Journal*, Vol. 89, March 1970, pp. 120-26.

Lansing, J. B. and J. N. Morgan. "The Effect of Geographical Mobility on Income," *Journal of Human Resources*, Vol. II, No. 4, Fall 1967, pp. 449-60.

Lansing, J. B. and E. Mueller, eds. *The Geographic Mobility of Labor*. Ann Arbor, Mich.: University of Michigan, Institute for Social Research, Survey Research Center, 1967.

Long, L. H. "Migration Differentials by Education and Occupation: Trends and Variations," *Demography*, Vol. 10, No. 2, May 1973, pp. 243-58.

Mincer, J. "Family Migration Decisions," *Journal of Political Economy*, Vol. 86, No. 5, October 1978, pp. 749-73.

Polachek, S. and F. Horvath. "A Life Cycle Approach to Migration," In *Research in Labor Economics*, R. Ehrenberg, ed. Greenwich, Conn.: JAI Press, Inc., 1977.

Psacharopoulos, G. and K. Hinchliffe. "Further Evidence on the Elasticity of Substitution Among Different Types of Educated Labor," *Journal of Political Economy*, Vol. 80, No. 4, July/August 1972, pp. 786-92.

Schroeder, L.D. "Interrelatedness of Occupational and Geographic Labor Mobility," *Industrial and Labor Relations Review*, Vol. 29, No. 3, April 1976.

Social Security Administration, Office of Research Statistics. *Interindustry Labor Mobility in the United States, 1957 to 1960*, Research Report No. 18 by L. E. Gallaway. Washington, D.C.: U.S. Government Printing Office, 1967.

Sommers, D. and A. Eck. "Occupational Mobility in the American Labor Force, *Monthly Labor Review*, January 1977.

Sommers, P. M. and D. B. Suits. "Analysis of Net Interstate Migration," *Southern Economic Journal*, Vol. 40, October 1973, pp. 193-201.

Wash, P. "Occupational Mobility of Health Workers," *Monthly Labor Review*, May 1977.

Wertheimer, R. F., III. *The Monetary Rewards of Migration Within the U.S.* Washington, D.C.: The Urban Institute, 1970.

Wolfle, D. *The Uses of Talent*. Princeton, N.J.: Princeton University Press, 1971.

appendix c

statistical tables

C-1. Occupational mobility of experienced scientists and engineers: 1972-78 16

C-2. Average annual occupational mobility rates of experienced scientists and engineers by age group: 1972-78 17

C-3. Average annual occupational mobility rates of experienced scientists and engineers by degree level: 1972-78 17

C-4. Average annual occupational mobility rates of experienced scientists and engineers by race: 1972-78 18

C-5. Average annual occupational mobility rates of experienced scientists and engineers by sex: 1972-78 18

C-6. Average annual occupational mobility rates of experienced scientists and engineers by selected characteristics: 1972-78 and 1968-72 19

C-7. Selected characteristics of the experienced scientists and engineers of 1972 in 1978 19

Table C-1. Occupational mobility of experienced scientists and engineers: 1972-78

Occupation in 1972	Occupation in 1978										
	Total	Physical scientists	Biological scientists	Mathematicians	Computer specialists	Psychologists	Social scientists	Other scientists	Engineers	Managers and administrators	Other non-scientists/ engineers
	In thousands										
Total	830.5	64.5	53.0	18.5	51.9	20.4	22.3	19.8	406.3	117.0	56.9
Physical scientists	80.3	56.9	2.4	.3	.6	(1)	.1	1.4	4.2	9.0	5.1
Biological scientists	67.8	2.7	48.6	.2	.1	.2	.5	.6	.8	6.1	8.1
Mathematicians[2]	27.6	.3	.1	13.1	1.9	(1)	.5	.1	2.1	3.5	2.9
Computer specialists	66.5	.3	(1)	.7	43.1	.1	.2	.3	4.8	13.1	3.8
Psychologists	24.1	(1)	.1	.1	(1)	19.2	.4	(1)	(1)	1.7	2.6
Social scientists	32.5	.2	.2	.4	.1	.6	20.4	.1	.2	5.0	5.5
Other scientists[3]	21.2	.8	.7	(1)	.1	(1)	.1	16.7	.7	1.5	.7
Engineers	510.5	3.5	.8	.6	5.6	.3	.2	.6	393.5	77.1	28.1
	Percent distribution										
Total	100.0	7.8	6.4	2.2	6.2	2.5	2.7	2.4	48.9	14.1	6.9
Physical scientists	100.0	70.8	3.0	(4)	1.1	(4)	(4)	1.7	5.2	11.3	6.4
Biological scientists	100.0	3.9	71.7	(4)	(4)	(4)	.7	.9	1.1	9.0	12.0
Mathematicians[2]	100.0	1.2	.5	58.4	6.8	(4)	1.8	(4)	7.7	12.5	10.5
Computer specialists	100.0	.5	(4)	1.1	64.9	(4)	(4)	.5	7.2	19.7	5.7
Psychologists	100.0	(4)	.6	(4)	(4)	79.6	1.5	(4)	(4)	7.1	10.6
Social scientists	100.0	(4)	.7	1.3	(4)	1.9	62.8	(4)	.5	15.3	17.0
Other scientists[3]	100.0	3.7	3.1	(4)	.5	(4)	(4)	78.6	3.3	6.8	3.3
Engineers	100.0	.7	(4)	(4)	1.1	(4)	(4)	(4)	77.1	15.1	5.5

[1] Less than 50.
[2] Includes statisticians.
[3] Primarily environmental scientists.
[4] Not calculated because of small sample size.

Source: National Science Foundation

Note: Components may not add to totals because of rounding.

Table C-2. Average annual occupational mobility rates of experienced scientists and engineers by age group: 1972-78

Occupation	Under 35	35-44	45 and over
Physical scientists, total	6.5	5.0	4.2
Administrative and managerial	2.0	2.2	1.6
Other non-science/engineering	2.0	1.0	0.8
Other science/ engineering	2.5	1.8	1.8
Biological scientists, total	7.4	4.6	4.1
Administrative and managerial	2.2	1.6	1.3
Other non-science/engineering	3.8	1.7	1.8
Other science/engineering	1.4	1.3	1.0
Mathematicians, total	7.9	6.9	6.4
Administrative and managerial	2.5	2.1	1.8
Other non-science/engineering	1.7	1.5	2.0
Other science/engineering	2.7	3.3	2.6
Computer specialists, total	5.5	6.0	5.9
Administrative and managerial	3.3	3.4	3.0
Other non-science/engineering	1.0	1.0	.8
Other science/engineering	1.2	1.6	2.1
Psychologists, total	3.1	4.1	3.2
Administrative and managerial	1.2	1.5	1.0
Other non-science/engineering	2.6	1.4	1.8
Other science/engineering	(1)	1.2	.4
Social scientists, total	8.7	5.9	5.4
Administrative and managerial	3.9	2.5	2.1
Other non-science/engineering	3.8	2.9	2.4
Other science/engineering	1.0	.5	1.0
Other scientists, total	5.1	3.9	3.1
Administrative and managerial	1.5	1.0	1.2
Other non-science/engineering	.6	.7	.5
Other science/engineering	3.0	2.2	1.4
Engineers, total	5.1	4.1	3.2
Administrative and managerial	3.1	2.9	2.1
Other non-science/engineering	1.6	.8	.8
Other science/engineering	.4	.4	.3

(1) Not estimated because of small sample size.

Source: National Science Foundation

Table C-3. Average annual occupational mobility rates of experienced scientists and engineers by degree level: 1972-78

Occupation	Bachelor's	Master's	Doctorate
Physical scientists, total	5.5	6.0	3.7
Administrative and managerial	2.1	2.6	1.5
Other non-science/engineering	1.4	1.4	.6
Other science/engineering	2.1	2.0	1.6
Biological scientists, total	5.9	6.1	3.4
Administrative and managerial	2.3	1.9	1.0
Other non-science/engineering	2.3	2.9	1.2
Other science/engineering	1.3	1.3	1.2
Mathematicians, total	9.5	8.1	4.5
Administrative and managerial	2.7	2.8	1.1
Other non-science/engineering	2.4	1.6	1.4
Other science/engineering	4.4	3.7	2.0
Computer specialists, total	5.3	6.8	6.1
Administrative and managerial	3.2	3.8	1.5
Other non-science/engineering	.9	.8	1.8
Other science/engineering	1.2	2.2	2.8
Psychologists, total	(1)	3.6	3.1
Administrative and managerial	(1)	1.3	1.0
Other non-science/engineering	(1)	1.8	1.7
Other science/engineering	(1)	.5	.4
Social scientists, total	(1)	7.5	3.8
Administrative and managerial	6.0	3.1	1.1
Other non-science/engineering	3.8	3.3	1.9
Other science/engineering	(1)	1.1	.8
Other scientists, total	4.1	2.8	3.4
Administrative and managerial	1.3	.9	1.2
Other non-science/engineering	.6	.3	.6
Other science/engineering	2.2	1.6	1.6
Engineers, total	3.7	3.9	3.6
Administrative and managerial	2.5	2.8	1.7
Other non-science/engineering	.9	.7	.5
Other science/engineering	.3	.4	1.4

(1) Not estimated because of small sample size.

Source: National Science Foundation

Table C-4. Average annual occupational mobility rates of experienced scientists and engineers by race: 1972-78

Occupation	Black	Asian	White
Physical scientists, total	3.8	2.4	4.9
Administrative and managerial	1.0	.9	2.0
Other non-science/engineering	1.5	.2	1.1
Other science/engineering	1.3	1.3	1.8
Biological scientists, total	6.1	3.3	4.7
Administrative and managerial	.7	.8	1.6
Other non-science/engineering	4.9	.8	2.0
Other science/engineering	.5	1.7	1.1
Mathematicians total	(1)	(1)	7.1
Administrative and managerial	(1)	(1)	2.2
Other non-science/engineering	(1)	(1)	1.7
Other science/engineering	(1)	(1)	3.2
Computer specialists, total	7.0	(1)	5.9
Administrative and managerial	4.8	(1)	3.3
Other non-science/engineering	.8	(1)	1.0
Other science/engineering	1.4	(1)	1.6
Psychologists, total	(1)	(1)	3.3
Administrative and managerial	(1)	(1)	1.2
Other non-science/engineering	(1)	(1)	1.8
Other science/engineering	(1)	(1)	.3
Social scientists, total	(1)	(1)	6.1
Administrative and managerial	(1)	(1)	2.6
Other non-science/engineering	(1)	(1)	2.7
Other science/engineering	(1)	(1)	.8
Other scientists, total	(1)	(1)	3.5
Administrative and managerial	(1)	(1)	1.2
Other non-science/engineering	(1)	(1)	.5
Other science/engineering	(1)	(1)	1.8
Engineers, total	4.5	.3	3.9
Administrative and managerial	3.3	1.2	2.6
Other non-science/engineering	.8	.6	.7
Other science/engineering	.4	.5	.4

(1) Not estimated because of small sample size.

Source: National Science Foundation

Table C-5. Average annual occupational mobility rates of experienced scientists and engineers by sex: 1972-78

Occupation	Male	Female
Physical scientists, total	4.8	6.3
Administrative and managerial	1.3	1.6
Other non-science/engineering	.9	3.3
Other science/engineering	2.0	1.4
Biological scientists, total	4.4	6.8
Administrative and managerial	1.5	1.6
Other non-science/engineering	1.6	4.5
Other science/engineering	1.3	.7
Mathematicians, total	7.1	6.1
Administrative and managerial	2.3	.7
Other non-science/engineering	1.5	3.4
Other science/engineering	3.3	2.0
Computer specialists, total	6.1	3.7
Administrative and managerial	3.5	1.9
Other non-science/engineering	.9	1.3
Other science/engineering	1.5	.5
Psychologists, total	3.3	3.7
Administrative and managerial	1.2	1.2
Other non-science/engineering	1.8	1.8
Other science/engineering	.3	.7
Social scientists, total	5.7	8.0
Administrative and managerial	2.5	2.7
Other non-science/engineering	2.5	4.1
Other science/engineering	.7	1.2
Other scientists, total	3.6	(1)
Administrative and managerial	1.2	(1)
Other non-science/engineering	.5	2.7
Other science/engineering	1.9	(1)
Engineers, total	3.8	5.5
Administrative and managerial	2.5	1.8
Other non-science/engineering	.9	1.5
Other science/engineering	.4	2.2

(1) Not estimated because of small sample size.

Source: National Science Foundation

Table C-6. Average annual occupational mobility rates of experienced scientists and engineers by selected characteristics: 1972-78 and 1968-72

Occupation and period	Sex		Highest degree			Age			Race		
	Male	Female	Bachelor's	Master's	Ph.D	Under 35	35-44	45 and older	Black	White	Asian
1972-78											
Physical scientists	4.8	6.3	5.6	6.0	3.7	6.5	5.0	4.2	3.8	4.9	2.4
Biological scientists	4.4	6.8	5.9	6.1	3.4	7.4	4.6	4.1	6.1	4.7	3.3
Mathematicians	7.1	6.1	9.5	8.1	4.5	7.9	6.9	6.4	(1)	7.1	(1)
Computer specialists	6.1	3.7	5.3	6.8	6.1	5.5	6.0	5.9	7.0	5.9	(1)
Psychologists	3.3	3.7	(1)	3.6	3.1	4.1	3.2	3.2	(1)	3.3	(1)
Social scientists	5.7	8.0	(1)	7.5	3.8	8.7	5.9	5.4	(1)	6.1	(1)
Other scientists	3.6	(1)	4.1	2.8	3.4	5.1	3.9	3.1	(1)	3.5	(1)
Engineers	3.8	5.5	3.7	3.4	3.6	5.1	4.1	3.2	4.5	3.9	2.3
1968-72											
Physical scientists	[illegible]	5.8	5.8	10.2	[illegible]	5.5	6.9	5.3	(2)	(2)	(2)
Biological scientists	5.1	7.7	4.9	7.1	5.3	5.3	5.3	6.1	(2)	(2)	(2)
Mathematicians	9.3	7.7	13.9	7.8	3.3	9.3	8.5	8.7	(2)	(2)	(2)
Computer specialists	4.1	2.1	2.2	4.8	9.4	3.5	4.3	6.2	(2)	(2)	(2)
Psychologists	3.1	4.1	(1)	2.9	3.6	2.7	4.4	3.7	(2)	(2)	(2)
Social scientists	4.1	4.5	4.1	3.0	4.3	3.5	5.3	4.9	(2)	(2)	(2)
Other scientists	3.4	2.0	2.4	3.9	4.1	3.3	3.3	3.0	(2)	(2)	(2)
Engineers	4.1	8.8	4.3	4.1	4.5	4.0	4.7	4.4	(2)	(2)	(2)

[1] Not estimated because of small sample size.
[2] Not available.

Source: National Source Foundation

Table C-7. Selected characteristics of the experienced scientists and engineers of 1972 in 1978

Occupation	Total	Sex		Race			Age			Degree level		
		Male	Female	White	Black	Other[1]	Less than 35	35-44	45 and over	Bachelor's	Master's	Doctorate
	(In thousands)											
Total	830.5	788.8	41.7	796.8	9.3	24.4	126.7	310.1	393.6	434.6	205.5	153.0
Physical scientists	64.5	60.8	3.7	60.0	1.3	3.2	8.2	25.7	30.6	21.0	11.7	31.6
Biological scientists	53.0	46.8	6.2	50.0	.9	2.2	5.7	21.2	26.1	12.2	9.3	29.7
Mathematicians[2]	18.5	16.0	2.5	16.9	.7	.9	3.4	7.7	7.4	3.5	5.9	8.9
Computer specialists	51.9	45.7	6.2	49.9	.7	1.1	13.2	25.3	13.4	32.2	15.2	3.7
Psychologists	20.4	15.2	5.3	20.0	.4	.1	3.5	7.4	9.5	.5	5.7	14.2
Social scientists	22.3	18.1	4.2	21.6	.2	.5	3.3	8.2	10.7	2.4	6.3	13.5
Other scientists[3]	19.8	19.2	.6	19.5	(4)	.2	1.8	6.5	11.5	8.0	5.4	6.3
Engineers	406.3	404.8	1.5	390.2	2.7	13.4	52.0	139.8	214.5	260.3	99.0	23.7
Managers and administrators	117.0	112.8	4.2	114.0	1.4	1.6	21.9	49.3	45.8	67.2	33.4	11.7
Other	56.9	49.2	7.6	54.6	1.1	1.2	13.8	19.0	24.1	26.9	13.6	9.7
Percent who changed occupation, 1972-78	26.0	25.6	34.5	26.2	32.0	19.2	34.4	27.6	22.0	25.4	29.1	22.0

[1] Primarily Asian.
[2] Includes statisticians.
[3] Primarily environmental scientists.
[4] Less than 50.

Source: National Science Foundation

OTHER SCIENCE RESOURCES PUBLICATIONS

Science Resources Studies Highlights

	NSF No.	Price
S/E Personnel		
"Decline in Recent Science and Engineering Doctoral Faculty Continues into 1978"	79-301	----

Detailed Statistical Tables

	NSF No.	Price
R&D Funds		
Research and Development in Industry, 1978. Funds, 1978, Scientists and Engineers, January 1979	80-307	----
Research and Development in State and Local Governments, Fiscal Year 1977	79-327	----
Academic Science: R&D Funds, Fiscal Years 1978	79-320	----
Federal Funds for Research and Development, Fiscal Years 1978, 1979, and 1980, Volume XXVIII	79-318	----
S/E Personnel		
Employment of Scientists, Engineers, and Technicians in Manufacturing Industries, 1977	80-306	----
U.S. Scientists and Engineers, 1978	80-304	
Academic Science: Scientists and Engineers, January 1979	79-328	----
Characteristics of Experienced Scientists and Engineers, 1978	79-322	----
Academic Science: Graduate Enrollment and Support, Fall 1978	79-316	----
Characteristics of Doctoral Scientists and Engineers in the United States, 1977	79-306	----

Reports

	NSF No.	Price
R&D Funds		
Federal Funds for Research and Development, Fiscal Years 1978, 1979, and 1980, Volume XXVIII	80-315	$3.75
Federal Support to Universities, Colleges and Selected Nonprofit Institutions, Fiscal Year 1978	80-312	$5.50
S/E Personnel		
Science and Engineering Personnel: A National Overview	80-316	$4.25
Employment Patterns of Academic Scientists and Engineers, 1973-78	80-314	$1.75
Projections of Science and Engineering Doctorate Supply and Utilization, 1982 and 1987	79-303	$2.25
Composite		
National Patterns of Science and Technology Resources, 1980	80-308	$3.75
Academic Science: 1972-77, R&D Funds, Scientists & Engineers, and Graduate Enrollment and Support	80-313	$4.25

Reviews of Data on Science Resources

	NSF No.	Price
R&D Funds		
No. 35. "State and Local Government R&D Expenditures, FY 1977"	80-302	$1.25
No. 33. "U.S. Industrial R&D Spending Abroad"	79-304	$0.70
S/E Personnel		
No. 36. "Employment Characteristics of Recent Science and Engineering Graduates: The Effects of Work Experience, Advanced Degrees, and Business Cycles"	80-311	$1.50
No. 34. "Sex and Ethnic Differentials in Employment and Salaries Among Federal Scientists and Engineers"	79-323	$1.00